Chapter 1 Basic Direction in Human Resource Development

People are the main actors in promoting science, technology and innovation. One of the most important pillars of the policy for science, technology and innovation is determining how to develop, secure and promote the activities of people as human resources.

Based on this understanding and on *the Science and Technology Basic Plan*, Japan has been promoting various measures for developing and securing human resources that foster science, technology and innovation, and has been providing opportunities for abilities to be fully exerted. The improvement of economic support for excellent students, the establishment of centers for world-class education and research, the development of research environments for young researchers including postdoc researchers, and the development of various career paths, including those in industry, have all been promoted. The mobility of faculty members and researchers has been promoted by introducing a "term-limit system" at universities and public research institutions. The participation of female and non-Japanese researchers has been promoted. Young researchers have been encouraged to study abroad. Human resources of the next generation are being fostered.

National research have been designated as independent administrative agencies, and national universities designated as corporations. Researchers and faculty members at these former national organizations no longer have civil servant status. These organizational changes eased the limitations that resulted from the personnel affairs system, which was an impediment in the promotion of research. The changes also promoted improvements in the environment in which the human resources of the institutions apply their abilities.

Through these measures, the quality and number of research papers from Japan are steadily increasing. The numbers of the research collaborations among industry-university-government research institutes are increasing. Researches which various disciplines need to converge are promoted. World-class basic research results, including the establishment of human iPS cells, have been achieved. Interest in Japan's abilities in science and technology (S&T) from other parts of the world has remained high[1].

Other countries have implemented their own approaches to science, technology and innovation. Japan's status in terms of the number of research papers published has been declining, because of advances made by other countries, and Japan's representation in research activities around the world has been declining.

In addition to these international circumstances, the socioeconomic conditions within Japan have been constantly changing. The population has begun to decrease because of low birth rates and demographic aging. The needs of people and society have diversified because of the maturation of society. The worldwide utilization of knowledge, technologies and human resources has become important amidst ever-progressing globalization. With the development of knowledge-based societies, the creation of new knowledge and technological innovation has been progressing faster than ever.

In light of this, to further promote science, technology and innovation in Japan and to compete internationally, it is imperative for Japan to realize reforms in systems for developing, securing and

1 For the basic research results that were achieved after the organizational changes, examples are discussed in *Feature 2* and *Columns 1-1 to 1-5, The Results of the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST)*.

invigorating human resources and to appropriately address the changes in socioeconomic conditions. The measures taken by Japan thus far have not clearly shown the effect of enhancing the nation's international competitiveness. Japan must clarify the factors that have contributed to the present circumstances and must show clear directions for new reforms.

This chapter starts by clarifying the most important aspects of activities for science, technology and innovation in the context of domestic and international socioeconomic changes. Therefore, the issues that need to be addressed are identified, by analyzing the state of human resources for science, technology and innovation. Based on the identified issues, a basic direction for promoting human resource development in the future will be presented.

Column 1-1

One Result from the Funding Program for World-Leading Innovative R&D (FIRST)

-The Development of a Next-generation Mass Spectrometry System, and Contribution to Drug Discovery and Diagnostics-

FIRST was initiated in FY2009 as a five-year innovative R&D support funding program. Under this program, which gives top priority to researchers, the world-class research results of 30 core researchers have been reported one after another. Some of these results are introduced below.

Koichi Tanaka, who won the Nobel Prize in Chemistry in 2002 and who is the Director of the Koichi Tanaka Laboratory of Advanced Science and Technology at Shimadzu Corp., pursued the development of a next-generation mass spectrometry system that can be used for the early diagnosis of diseases and for the development of new drugs.

Test model of the next-generation mass spectrometry system
Courtesy of Shimadzu Corp.

To efficiently measure minute amounts of disease-induced substances that exist in the human body, existing mass spectrometry systems were improved. Part of the antigen that captures the target substance was made into a spring structure, which makes it possible to capture the substance more efficiently. A matrix material that enhances the ionization efficiency of the substance was also developed. The new system has 10 thousand times the sensitivity of conventional systems. As a result, substances in blood and urine that enable the early detection of breast cancer, prostate cancer and Alzheimer's disease are detectable. The system is expected to contribute to enhanced diagnostic accuracy, and application of the system will lead to the early detection of diseases and to the elucidation of the causes of various diseases.

1 Funding Program for World-Leading Innovative R&D on Science and Technology

Section 1 Socioeconomic Changes and Science, Technology and Innovation Activities

1 Demographic Aging with a Declining Birthrate, and the Maturation of Society

Birth rate declines and demographic aging have been rapidly progressing in Japan. The population has already begun to decline. The National Institute of Population and Social Security Research published the report *Population Projection for Japan* in January 2012. The projected populations based on mid-range estimates for birth rate and death toll are as follows. The population of Japan, which was 128,060,000 in 2010, has entered a period of long-term decline. It is projected to decrease to 116,620,000 as of 2030, and to drop to 99,130,000, below the 100 million mark, by 2048. In light of such circumstances, it has become important to know how to secure human resources capable of taking responsibility for science, technology and innovation as well as how to cultivate the abilities of such individuals.

At the same time, the needs of people and society have been changing. Richness of mind will be considered more important than material wealth. Quality-of-life improvements, including those of health, safety and security, have been strongly sought by the people. As many people have come to enjoy a certain level of affluence, their needs have diversified. Not only are people interested in possessing things, they are also interested in enjoying the quality of service and aesthetic aspects, such as design, that those things offer. Therefore, for the creation of value through science, technology and innovation, a variety of knowledge, viewpoints and ideas are required in appropriately addressing these diversifying needs.

2 Progress in Globalization

Globalization has been seen to increase progress because of developments in communications and transportation technologies.

Various activities of society have become borderless. This is true in science, seen in such activities as solving global-scale issues, including environmental problems. Opportunities for researchers around the world to coordinate and cooperate across national boundaries and disciplines have been dramatically increasing. When solving complex problems that require the involvement of many countries and many fields of research, a variety of knowledge, ideas and global viewpoints are increasingly required.

The movement of information and people across national borders has increased. Not only does the utilization of domestically available knowledge, technologies and excellent human resources greatly influence research achievement, but so too does the utilization of those from wide areas of the world. Toward the realization of superior research achievements, it is important for excellent researchers to form international research networks and to cooperate across borders.

At the same time, many countries have been promoting efforts to recruit the best human resources, which has intensified international competition for "brain gain." Many countries are using preferential measures to recruit highly skilled human resources by smoothing entry requirements, residence permissions, and by expanding the acceptance of foreign students, who are future highly skilled human resources. It is important for Japan to strategically secure more of these human resources.

3 Progress in Our Knowledge-based Society

With the advent of the 21st century, advanced counties have begun to shift from industrialized societies, based on mass production and mass consumption, to knowledge-based societies, in which knowledge has dramatically increased in importance as the basis of activities in every area of society.

The utilization of knowledge generates new knowledge. Knowledge of one kind fuses with knowledge of another in the course of utilization, and the quality of knowledge improves. New knowledge is generated daily in this way. Together with the dramatic development and dissemination of communications technologies, the generated knowledge is instantaneously transmitted as information to many parts of the world. Many people around the world are able to access and apply that knowledge and information. The utilization of knowledge accelerates economic development in emerging countries as well as in advanced countries, and the transition to knowledge-based society has already started in some emerging countries.

Under these circumstances, qualitative changes in knowledge-based societies have occurred. As the amount of knowledge and information has been growing at an accelerating pace, knowledge and information have become subdivided into small segments that are more specialized and diverse in quality. Simply collecting knowledge and information is not useful in generating new value. What is important is to cull and collate essential knowledge and information from the massive amount of collected knowledge and information, and thereby generate new value. As knowledge has become an infrastructure, large amounts of knowledge and information need to be efficiently utilized. Thus, knowledge-based societies have been progressing to a full-fledged stage.

Amidst such circumstances, changes have been occurring in the creation of new knowledge and information, and in problem-solving that relies on the newly created knowledge and information.

Specifically, it has become easy for many people to obtain knowledge and information. The trend of quick decreases in the value of widely published knowledge and information has intensified. Therefore, the value of tacit knowledge that cannot be expressed in words or be distributed as information has been increasing. It is extremely important to secure and utilize highly skilled human resources who possess such profound expertise for the creation of new value.

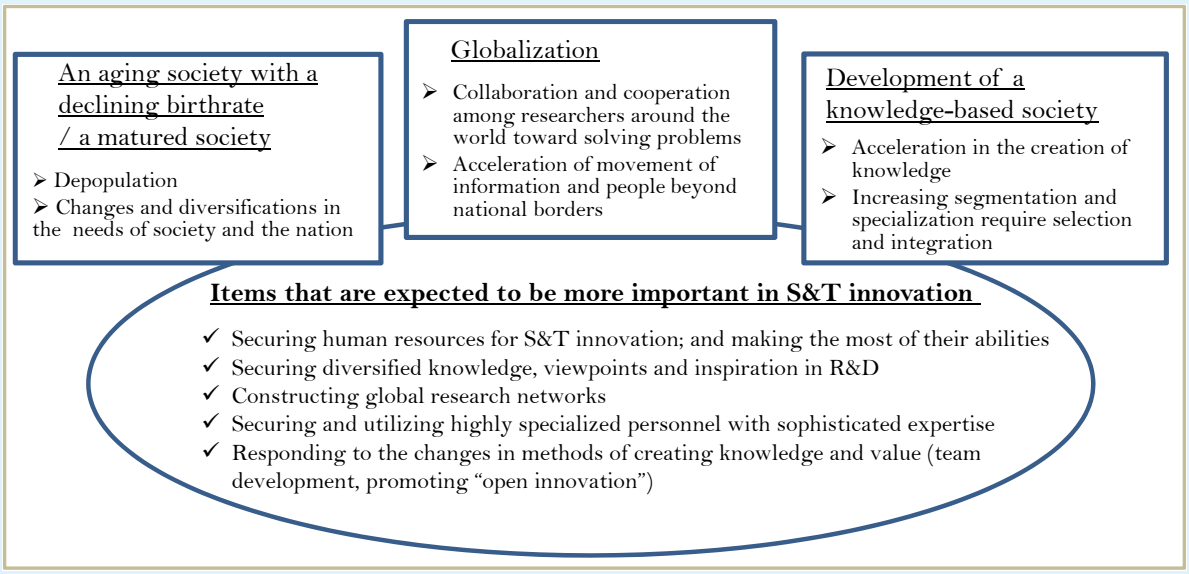
At the same time, it has become difficult for individuals to equip themselves with knowledge and techniques required for the creation of new value. It is required that human resources with highly specialized knowledge and abilities who possess knowledge, viewpoints and ideas in various areas gather in teams and work toward the creation of new value. In keeping with this, it is important to have new research systems, under which researchers are able to contribute to the creation of new value by appropriately managing teams consisting of diverse human resources.

In fostering innovation, a system called “open innovation” has already emerged. In open innovation, work is done not only by applying the knowledge and technologies of one’s own organization but also by actively using external resources. In Japan, growing out of the so-called in-house policy of R&D at companies is necessary. Promoting open innovation, not only by utilizing external resources such as in the Europe and the USA, but also by promoting collaboration among industry-university-government research networks and by forming consortiums is also necessary.

Socioeconomic conditions are changing, as seen in the emergence of demographic aging with declining birthrates, the maturation of society, progress in globalization and the development of knowledge-based

societies. Such changes are projected to influence the activities of science, technology and innovation in various ways. Figure 1-1-1shows the items that are projected to gain particular importance.

Figure 1-1-1 / Areas of Importance which will Increase with Socioeconomic Changes



Source: MEXT

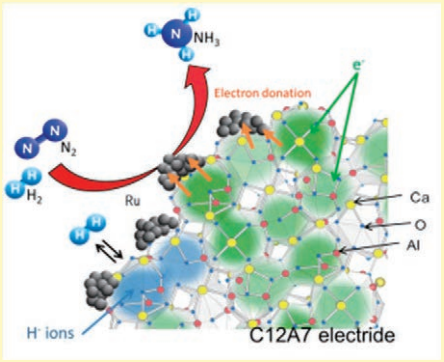
Column 1-2

One Result from the Funding Program for World-Leading Innovative R&D (FIRST)

– New Superconductivity, Investigation for Related Functional Substances, and Application of Industrial Superconducting Wire –

Professor Hideo Hosono of the Frontier Research Center at the Tokyo Institute of Technology has worked on investigations of new superconducting substances and the establishment of a technology for creating industrial superconducting wire.

Superconductivity is a phenomenon in which a metal or chemical substance achieves zero electrical resistance when cooled to a critical temperature. Superconducting substances have potential applications as electromagnets in power lines and in medical MRI. Toward realizing superconductivity at high temperatures, Professor Hosono undertook the investigation of superconducting substances with a high critical temperature. While working under FIRST, he discovered more than 60 new superconducting substances. He also succeeded in making superconducting wire with high current density by using iron-based superconductors. His research is another step toward practical application. In his previous research on semiconductors using transparent conductive oxides, Professor Hosono discovered that components of cement, used as an insulator, have the potential to be used as superconducting substances. By focusing on the strong electron-releasing property of substances, he discovered that highly efficient ammonia synthesis is possible from nitrogen and hydrogen when ruthenium particles are supported on the surface of the substance. Industrial applications are anticipated, because the medium enables synthesis at normal pressure, and the method is more energy efficient than the conventional Haber–Bosch process.



Model for a sophisticated ammonia synthesis reaction (Ruthenium-supported C12A electride)

Courtesy of Tokyo Institute of Technology